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Building Acoustic: Measurement and Analysis of Sound Levels in New Arts Theatre, Faculty of Arts Auditorium and University of Calabar Conference Hall

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Abstract
The noise generated in and within the surroundings of New Arts theatre, Faculty of Arts Auditorium and University of Calabar conference hall were measured and analysed. Acoustic survey (objective measurement) were carried out using digital sound level meter of Extech 407732 model, while social surveys(subjective measurement) was also conducted using questionnaires .The area of survey was divided into five data points and result noted. The results show that the A-weighted noise level for New Arts theatre, Faculty of Arts auditorium and University of Calabar Conference hall were 60.3dB, 49.5dB and 59.5db, while those of the surroundings were 80.6dB, 58.7dB and 76.6dB respectively. The corresponding noise pollution levels were also calculated to be 71.9dB, 58.6dB and 71.7dB inside the halls, while that of the surroundings were calculated to be 109.4dB, 71.9dB and 99.8dB respectively. The correlation coefficient between the subjective and objective measurements were calculated to be 0.91 for New Arts theatre, 0.41 for Faculty of Arts Auditorium and 0.81 for University of Calabar Conference hall. This shows that respondent in New Arts theatre reacted more uncomfortably to any change in sound level while respondents in Faculty of Arts auditorium reacted less to any change in sound level. From the results obtained, it is obvious that Faculty of Arts auditorium is best recommended for hosting programs that require less noise.
Keywords: Sound, Noise, Acoustic, Sound Level Meter,

1. Introduction

Sound is a disturbance of wave, which propagates through physical medium such as air or parts of the building structure in a longitudinal manner from the generating source to produce sensation of hearing at the receiving end (Olasoji & Akingbade, 2008).Noise is derived from the Latin word “Nausea” implying unwanted sound (omubo-Pepple, Briggs-Kamara, & Tamunobereton, 2010).It is said to occur when the noise level is above the maximum permissible level for a given environment (Federal Enironmental Protection Agency, 1995) (World Heath Organisation, 1980). Noise is a silent killer and prolonged exposure to low frequency noise can cause either permanent or temporary damage to hearing. The effect of noise on human emotions ranges from negligible through annoyance and anger to psychologically disruptive. Physiologically, noise can range from harmless to painful and physically damaging (A.O, M.U, A.I, & U.E, 2003).noise affect communities and resident in many ways, ranging from physiological to psychological effects such as hearing impairment, communication interference, sleeplessness, annoyance, ear irritation ,task interference and general discomfort (Magrab, 1975)- (Cunnif, 1977).The growth is commercial activities resulting in enormous increase in sound generated within the campus especially within the surroundings of lecture halls and auditoriums calls for serious concern.

2. Literature Review

2.1 Review of Fundamental Concept

2.1.1 Sound And Noise

Sound is a quickly varying pressure wave travelling through a medium. It is produced by alternating pressure changes in the air and caused by the vibrations of solid objects or separation of fluids as they pass over, around or through holes in solid objects. The vibrations caused the surrounding air to undergo compression, then rarefaction and soon. Such alternating compression and rarefaction of the surrounding air produces sound waves which propagate in the form of sinusoidal path.

Sound may be perceived as desirable or unwanted. It is this unwanted sound that is referred to as noise. The word noise comes from Latin root as the word “nausea” which means disgust or feeling of sickness (omubo-Pepple, Briggs-Kamara, & Tamunobereton, 2010). Noise and Sound are physically the same, differences arising in their acoustic quality as perceived by listeners. This leads to a definition of noise as undesired sound (Okpighe, 2015).Noise originates from human activities, especially the urbanization and the development of transport and industry. This noise can have serious harmful effect on humans ranging from physiological to psychological effects such as hearing impairment, communication interference, sleeplessness, annoyance, ear irritation, task interference and general discomfort (Obisung, O., & Ubon.E.Asuquo, 2013).

2.1.1 Noise Descriptors /Indices And Standards

1) $LAeq$ (equivalent continuous noise level)
It is that statistical value of sound pressure level that can be equated to any fluctuating noise level.

$$LAeq = 10Log\frac{1}{T}\int_0^T 10\,L(t)/10$$

$$Or\ LAeq = 10Log\sum_{i=1}^{1=n} 10\frac{Li}{10}$$

$$Li = The\ noise\ level\ in\ dB(A)\ of\ the\ ith\ sample$$

t_i=*fraction of total samples taken*

$$n = the\ number\ of\ samples\ taken$$

(Obisung, Akpan, & Asuquo, 2013)

2) *Noise pollution Level (L_{NP})*
$L_{NP} = L_{eq} + (L_{10} - L_{90})$ *dB*
Or
$L_{NP} = L_{eq} + 2.5\sigma$
L_{10} *=sound level exceeded 10% of observe time*
L_{90} *= sound level exceeded 90% of observe time*
σ *=standard deviation*

(Obisung, Akpan, & Asuquo, 2013)

3) $Day - Night\ A - weighted\ energy\ sound\ level$
$The\ equivalent\ noise\ level\ during\ 24hours\ time\ period\ represented\ by$ L_{dn}*(Day-Night A-weighted energy sound level)*

(Obisung, Akpan, & Asuquo, 2013)

$$Ldn = LAeq(24hrs) = 10Log\frac{1}{24}\sum_{i=1}^{1=n} 10\frac{Li}{10}$$

Where n_i,L_i and t_i have their usual meanings

4) $Noise\ exposure\ forecast(NEF)$
$NEF = L_{dn} = -35 \pm 3$

5) $Noise\ and\ Number\ index(NNI)$

$$NNI = 10Log10[\frac{1}{24}\sum_{i=1}^{1=n} 10\frac{Li}{10}] + 15LogN - 67$$

$$i.e\ NNI = Ldn + 15LogN - 67$$

Noise Standards
In other to protect the health of the public various standard have been designed by the World Health Organisation (WHO) and Federal Environmental Pollution Agency (FEPA) as shown below

Table1 (WHO 1980 and FEPA 1995)

TYPES OF ROOMS	**ALLOWABLE SOUND LEVEL dB(A)**
Conference room	35
Offices	40
Workshop	45
Laboratory measurement room	50
Production area(factory)	75

Table2 (WHO, 1980 and FEPA, 1995)

SITUATION	**ACCEPTABLE SOUND LEVEL dB(A)**
Working Environment(8 hours per day)	75
Bedroom inside at night	35
Indoor background level to ensure good speech intelligibility	45
Outdoor level at daytime	55
Outdoor level at night	45

2.2 Review of Similar Works

Several researchers have studied the effect of noise on man and his environment in different ways. Akpan and Onuu in their investigation of levels and spectra of industrial noise in southern-eastern Nigeria found that noise spectra produced in the industries were fairly Gaussian (or white type) with characteristic peak at 2KHz.They also discovered that some industries in southern-eastern Nigeria generated noise levels that exceeded the 90dBA

recommendation for daily exposure time of 8hours (Akpan, Onuu, Mentiki, & Asuquo, 2002).

Olasoji & Akingbade(2008) Investigated and comparatively analyzed the acoustic properties of different enclosures (University auditorium, ETF lecture theatre, center for continuing education multipurpose hall and chapel of faith at Federal University of Technology Akure).Their inference shows that the auditorium is having the best acoustic characteristics based on the influential factors such as Cellotex ceiling, which reduce reverberation time and octagonal shape of the building walls to permit even distribution of sound.

GO & NTE(2003) Carried out measurements of environmental sound quality of some selected flow stations in the Niger-delta area of Nigeria. His result were slightly below FEPA recommended permissible limit for maximum of 8 hours and hence hazardous and environmentally unfriendly to the society.

A.S.Aremu, Omoniyi, & saka(2015)Assessed indoor noise at University of Ilorin main library in Nigeria. His results showed that most of the noise levels were higher than the recommended maximum limit of 45 decibels. He suggested that a noise policy should be formulated for the library in addition to acoustic upgrading and library space reclassification.

Obisung, Akpan, & Asuquo(2013)Surveyed community reactions to aircraft/airport noise for 12months(march 2002 – February 2003).Their result revealed 83% of the residents described aircraft noise as a public nuisance, 98% described Nigerian airports noisily disturbing, 94% admitted their lives are damaged in one way or the other, and 87% wanted airport/aircraft noise controlled.

Essandoh & Armah(2011) Studied and quantified noise at five selected areas in the main commercial area of Cape Coast, Ghana. Their result reveal that about 82.1% of the respondents complained that the noise from the audio music shops and traffic is a nuisance. They also discovered that noise levels at all the 10 measurement points exceeded the Ghana EPA recommended upper limit by values of 1-15 dB (A).

O.W & S.M (2013) Investigated the presence of Noise pollution in University of Uyo. They measured the noise levels of electricity generating sets and the concomitant pollution level in the University. Their result clearly shows that the noise pollution level in University of Uyo is high and reaches a peak level of 89.5dB(A) during the hours of 11 – 12pm while generating sets noise level reaches a maximum value of 95.2dB(A).They also discovered that the noise emission level within the university exceeded the maximum allowable noise level which ranges between 40dB(A) to 50dB(A) recommended for educational institutions and could produce noise pollution problems leading to annoyance, lack of concentration, interfering with communication and causing general stress, low productivity and increasing work absenteeism.

(Okoro(2014) Carried out a survey and analysis of Noise from generating plants in the Northern part of University of Calabar. His results show that the average ambient noise level and A-weighted noise level were 100.43dB (A) and 99.40dB (A).his result from his social survey indicated that 72% of respondents agree that generator noise is a nuisance and 94% agreed that noise should be controlled.

3. Site Location And Survey

The New Arts Theatre (NAT) is located at the main campus of the University of Calabar at an elevation of 69m above sea level.it is located within latitude and longitude of $N04^{0}57^{I1}0.3^{II}$ and $008^{0}20^{I}25.4^{II}$ at about 50metres from the main gate .It is one of the biggest hall in the university and use for events such as convocation ceremonies/lectures, cultural display, church programs among other public events.

The Faculty of Arts auditorium is located within axis of University of Calabar Library at an elevation of 42m – 49m above sea level. It is located within latitude and longitude of $N04^{0}56^{I}53.8^{II}$ and $008^{0}20^{I}58.8^{II}$.

The University of Calabar Hotel is located along UNICAL Satellite town road, close to the University of Calabar Teaching Hospital (UCTH).

The major sources of Noise generated around includes Photocopy Machines, Generating Plants, Traffic noise and manmade noise. This generated noise around the Hall may interfere with communication and as well, causes certain health effects on the People.

The essence of this research is to ascertain the effects of such sound level and recommend possible ways to control and mitigate the effects.

4. Materials And Methods

4.1 Materials

4.1.1 Sound Level meter

A Sound Level Meter of model Extech 407732 instrument was used for the field measurement of noise level at selected areas within and outside the halls. A Sound Level Meter is an instrument which responds to sound in an approximately the same way as the normal human ear and which gives objective, reproducible measurements of sound levels. It measures Sound Pressure Levels or vibration acceleration levels and consists of a microphone, an amplifier with calibrated logarithmic alternator, a set of frequency response (weighting) network and an indicating meter with logarithm scale. The microphone detects the small air pressure vibration associated with sound and changes them into electrical signals. These signals are then amplified, processed by the electronic circuit of the instrument before it can be read on a meter. After the first amplification, the signal may pass through a weighting network (A, B, C or D). (A.O, M.U, A.I, & U.E, 2003).

4.1.2 Questionnaires

For Subjective assessment of impact noise on Student and People outside and inside the surroundings of the various halls under studies, Questionnaires were distributed .Part I covers the personal data while part II describes peoples complains, reactions and responses towards the generated noise. A total of 400 questionnaires were distributed per hall.

Other instrument used include Stop clock, GPS (global positioning system) device and Tripod stand

4.2 Method

Two methods (Physical and questionnaire) were adopted in carrying out this research and the relationship between the two measurements was calculated with the help of correlation analysis.

- Preliminary noise survey was carried out at various locations in and out of the halls to determine suitable measuring positions.
- Within the hours of 6.00am - 7and 10am – 5 pm for a period of one week, The background noise was also measured and noted at different site with the help of a Sound Level Meter adjusted to "A" weighting placed at a height of 1.2meter.
- Commonly use noise assessment quantities like the Exceeding Percentile (L_{10}, L_{90}), A-weighted Equivalent Continuous Sound Pressure Level (L_{Aeq}) and the Noise Pollution Level (LNP) were calculated.
- The average occurrence was recorded and correlated with result obtained from Questionnaires.

5. Results And Discussions

Table3: Summary of Equivalent Noise levels inside New Arts Theatre, Faculty of Arts Auditorium and University of Calabar Conference hall.

LOCATIONS	BNL	L_{Aeq}(dB)	L_{10}(dB)	L_{90}(dB)	L_{10}-L_{90}(dB)	L_{NP}(dB)
UCH	35.5	59.5	65.4	53.0	12.4	71.7
NAT	32.0	60.3	66.0	54.6	11.4	71.9
FAA	30.3	49.15	53.6	44.2.	9.4	58.6

Table4: Summary of Equivalent noise levels outside New Arts theatre, Faculty of Arts auditorium and University of Calabar Conference Hall

LOCATIONS	BNL	L_{Aeq}(dB)	L_{10}(dB)	L_{90}(dB)	L_{10}-L_{90}(dB)	L_{NP}(dB)
UCH	40.3	76.6	82.8	59.6	23.3	99.8
NAT	40.8	80.6	87.6	58.8	28.8	109.4
FAA	40.1	58.7	64.0	50.8	13.2	71.9

Table 5: Statistics of Questionnaire Distribution

LOCATIONS	NUMBER OF DISTRIBUTED QUESTIONNAIRES	VALID RESPONSE	PERCENTAGE
NAT	400	330	82.5
FAA	400	320	80
UCH	400	310	77.5

Table 6: Age Distribution of Respondent (Years)

LOCATIONS	IN YEARS			
	18-29	30-39	40-50	50 AND ABOVE
NAT	305	12	8	5
FAA	280	20	12	8
UCH	171	103	26	10

Table 7: Correlation between Objective and Subjective Responses in New Arts Theatre

MEASUREMENT SITE	X	Y	XY	X^2	Y^2	R
NAT 1	65.0	3.3	214.5	4225	10.89	
NAT 2	72.0	3.3	237.6	5184	10.89	
NAT 3	75.3	3.5	263.55	5670.09	12.25	**r=0.91**
NAT 4	65.3	3.1	202.43	4264.09	9.61	
NAT 5	79.5	3.1	246.45	6320.25	9.61	
TOTAL	**357.1**	**16.3**	**1164.53**	**25663.43**	**53.25**	

Table 8: Correlation between Objective and Subjective Responses for Faculty of Arts Auditorium

MEASUREMENT SITE	X	Y	XY	X^2	Y^2	R
FAA 1	55.5	3.3	183.15	3080.25	10.89	
FAA 2	58.6	3.2	187.52	3433.96	10.24	
FAA 3	48.8	3.1	151.28	2381.44	9.61	**r=0.41**
FAA 4	60.2	3.0	180.6	3624.04	9.00	
FAA 5	63.8	3.2	204.26	4070.44	10.24	
TOTAL	**286.9**	**15.8**	**906.71**	**16590.13**	**49.98**	

Table 9: Correlation between Objective and Subjective Responses for University of Calabar Conference Hall

MEASUREMENT SITES	X	Y	XY	X^2	Y^2	R
UCH 1	79.1	3.6	284.76	6256.81	12.96	
UCH 2	75.5	3.5	264.25	5700.25	12.25	
UCH 3	70.8	3.3	233.64	5012.64	10.89	**r=0.81**
UCH 4	82.0	3.5	287.00	6724.00	12.25	
UCH 5	80.8	3.6	290.88	6528.64	12.96	
TOTAL	**388.2**	**17.5**	**1360.53**	**30222.34**	**61.31**	

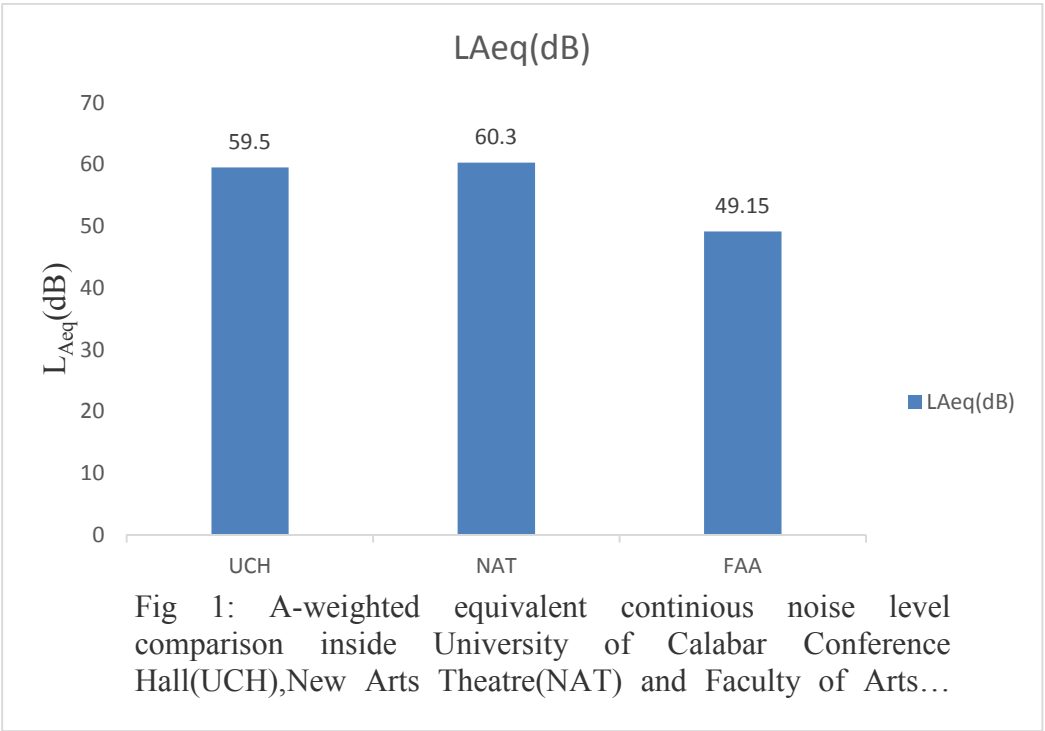

Fig 1: A-weighted equivalent continious noise level comparison inside University of Calabar Conference Hall(UCH),New Arts Theatre(NAT) and Faculty of Arts…

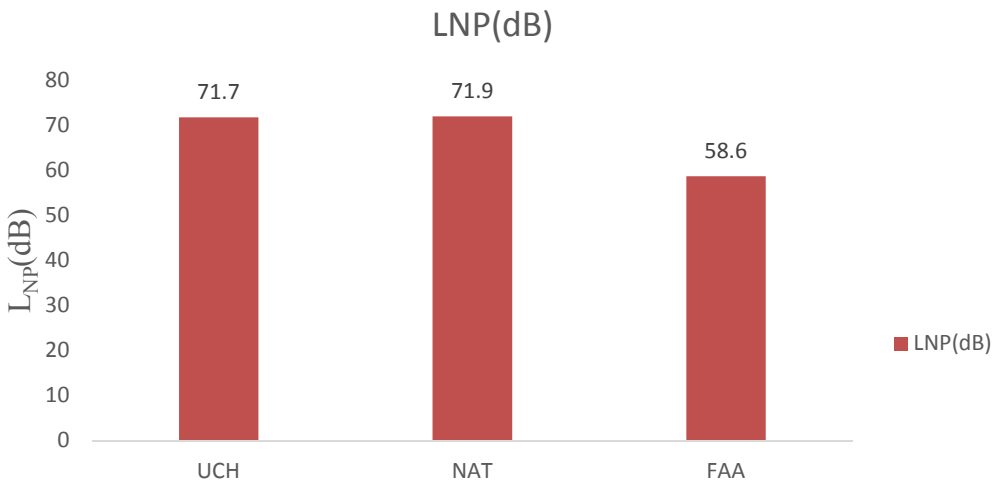

Fig 2:Noise pollution level comparison inside University of Calabar Conference Hall,New Arts Theatre and Faculty of Arts Auditorium

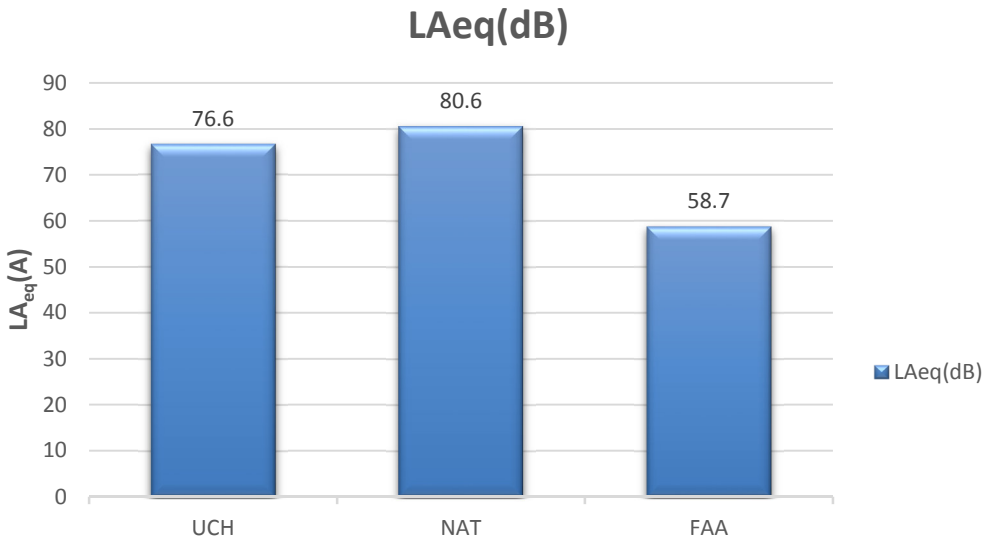

Fig 3: A-weighted continious noise level within the surroundings of University of Calabar Conference Hall(UCH),New Arts Theatre(NAT) and Faculty of Arts Auditorium(FAA)

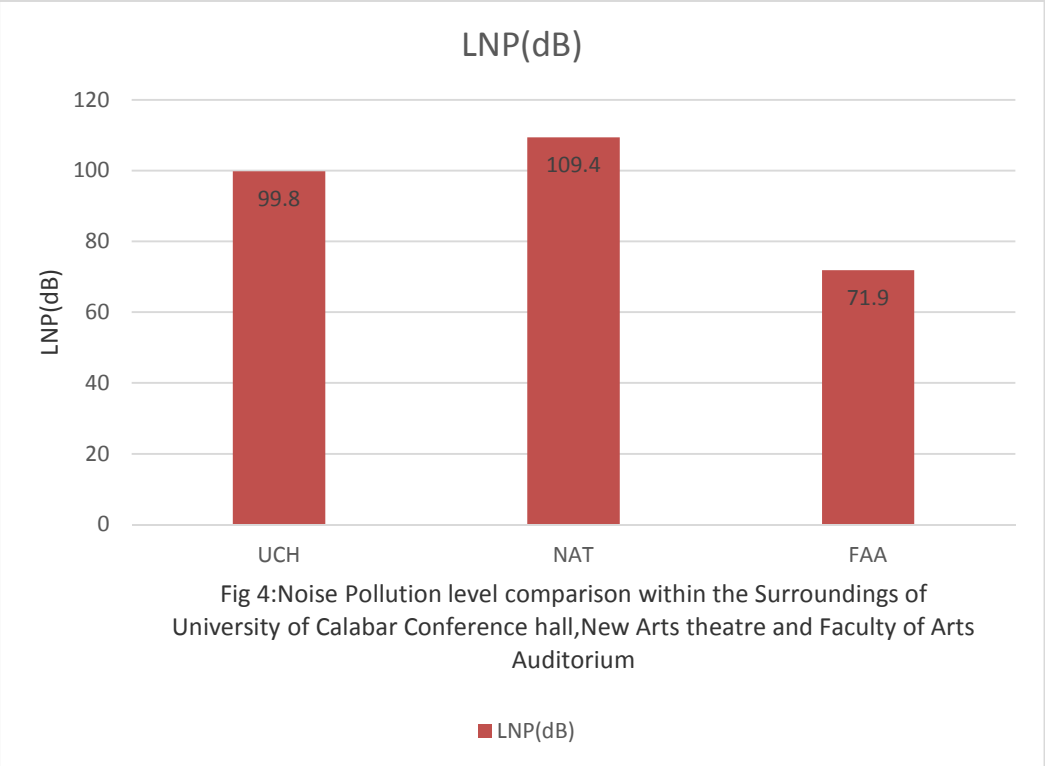

Fig 4:Noise Pollution level comparison within the Surroundings of University of Calabar Conference hall,New Arts theatre and Faculty of Arts Auditorium

Table 3-4 and Fig 1-4 Show the comparison of Sound generated in and within the surroundings of the Halls under study. From the result obtain it is clear that noise generated within the environment of New Arts Theatre is higher than that of Faculty of Arts Auditorium and University of Calabar Conference hall. This can be attributed to the enormous noise generated due to commercial activities such as Business Centres within the hall. Faculty of Arts Auditoriums is therefore recommended for Programs that require less Noise. Comparing Table 3-4 with World Health Organisation it was observe that long time exposure to noise generated within New Arts Theatre can cause hearing impairment and therefore, dangerous to health of audience and people within such area. Noise generated within the halls can cause psychological effect as well as annoyance.

Table 5 Shows the statistics of questionnaires distributed .As shown in Table 5, 82.5 percent of Questionnaires distributed were respondents in New Arts theatre, 80 percent were respondents in Faculty of Arts Auditorium while 77.5 percent were respondents in University of Calabar Conference Hall. More than 50 percent of respondents in New Arts theatre, Faculty of Arts Auditorium and University of Calabar Conference Hall suffers effect of annoyance, communication disturbance, mental fatigue, lack of concentration and increased blood pressure.

The correlation coefficient was obtained to be 0.90 for New Arts theatre, 0.41 for Faculty of Arts Auditorium and 0.81 for University of Calabar Conference Hall. This shows that respondents in New Arts Theatre reacts more to any change in sound level while respondents in Faculty of Arts Auditorium react less to any change in sound level. Therefore, Faculty of Arts Auditorium is better recommended for programs which require less noise.

6. Conclusion And Recommendation

The results show that the A-weighted noise level for New Arts theatre, Faculty of Arts auditorium and University of Calabar Conference hall were 60.3dB, 49.5dB and 59.5db, while those of the surroundings were 80.6dB, 58.7dB and 76.6dB respectively. The corresponding noise pollution levels were also calculated to be 71.9dB, 58.6dB and 71.7dB inside the halls, while that of the surroundings were calculated to be 109.4dB, 71.9dB and 99.8dB respectively.

The result obtain revealed that audience making use of New Arts Theatre as well as University of Calabar Conference Hall could suffer from physiological and psychological effect which include annoyance, communication disturbance, mental fatigue, hearing impairment and general discomfort. The studies also reveal that noise is actually a public nuisance.

The studies show that Faculty of Arts Auditorium is acoustically favoured among the three halls and best recommended for Programs that require less noise.

Based on information obtain from this research, in other to achieve a conducive acoustic atmosphere the

following noise mitigating measures were recommended:

1. Business centres and other commercial activities should be relocated to places at reasonable distance from the halls.
2. Use of renewable sources of energy as backup should be encouraged.
3. The school authorities should enact and enforce necessary laws which should aim as mitigating the noise pollution.
4. Regular power supply should be ensured in other to reduce the use of generating plants and private generators which constitute a major source of noise.
5. Proper sensitization should be carried out to create awareness of the effect of noise.
6. Since Plants, which are living organisms, can reduce noise, they should be planted around the halls as natural living noise barriers (Ozdemir, Bayramoglu, & Demirel, 2014).

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